SECTION 5

POTENTIAL PATHWAYS

5.0 Potential Pathways

5.1 General

5.1.1 Vegetation

Airborne particulate radioactivity may be deposited directly on the edible foliar surfaces of crops or on the soil and then migrate through the soil into the plant's root system and into an edible crop. Such crops may be consumed directly by man or by animals which are ultimately consumed by man. The use of contaminated water (either groundwater or surface) to irrigate crops may also lead to the ingestion of radionuclides from either the direct consumption of the crop or the crop-to-animal-to-man pathway.

The reconnaissance surveys of some inactive uranium mine sites indicated that no crops for human consumption were being farmed at or near any of the sites. Although the potential for man's ingestion of radionuclides in edible crops due to the direct deposition or the root uptake of either airborne particulates or contaminated mine water is a greater possibility near the active mines, farming in such areas is not extensive.

Almost every inactive and active mine site visited had range cattle and/or sheep grazing on the natural vegetation growing at the site; hence, the possible consumption of such animals could be a potential pathway for man's ingestion of radionuclides released into the environment surrounding the mine sites.

5.1.2 Wildlife

There are numerous species of mammals, birds, reptiles, and amphibians at both active and inactive uranium mine sites. Though mining may destroy their natural habitat, there are no significant radiological impacts on wildlife in these areas. Dewatering and drainage from active mines sometimes create ponds or streams that may be used by migratory waterfowl and local wildlife as a source of water, but, when mining is completed, the ponds dry up, probably without leaving any permanent or significant radiological impact on wildlife. The small lakes formed in inactive surface mine pits, however, may remain for a long period of time and have a significant environmental impact. It would be expected that sedimentation and eutrophication of the lakes would progressively diminish the impact with time by reducing the contact of ore bodies with the biosphere. The potential food pathway of animal-to-man via wildlife hunting at these sites is also minimal. Hunting is poor and hunting restrictions are usually observed at the mine sites.

5.1.3 Land Use

Most uranium mining activities have been conducted in areas away from population centers. Most mines are located on private property or are on Federal lands such as national forests. The predominant land use is as rangeland (or forest) and only minor areas are cropland. The fraction of land used for vegetable crop production for Wyoming and New Mexico is 1.59×10^{-3} and 1.38×10^{-3}, respectively. This fraction is based on the assumption that the statewide fractions apply to uranium mining areas within each state. Average population densities are typically rural, i.e., less than one person per 2.6 km^2.

5.1.4 Population Near Mining Areas

Uranium mines occur in clusters throughout many western states and are somewhat scattered throughout the eastern states. In order to estimate the number of persons residing within 50 miles (80km) of a mine, we used county populations where there either is or has been mining. Table 5.1 lists the states and their respective mining counties plus the numbers of inactive and active surface and underground uranium mines in each county. We derived the county population statistics from U.S. Department of Commerce census data (DOC78), which are January 1, 1975 estimates. The county areas were obtained from the same reference.

The area, 20,106 km^2, within a circle with a radius of 80 km usually exceeds the area of most counties. Because of this, the number of persons residing within 80 km of a mine will be underestimated using county population statistics. In other words, we consider the estimates of populations within the mining regions to be somewhat low.

Persons residing in a mining area are likely to be exposed from more than one mine because of the aforementioned clustering. To account for this, Table 5.1 lists the product (person-mines) for both active and inactive uranium mines. The total number of person-mines for inactive mines is approximately 82,000,000 persons. The total number of person-mines for active mines is approximately 14,000,000 persons. The combined equivalent population exposed to inactive and active uranium mining is approximately 96,000,000 persons.

Table 5.1 Number of uranium mines and population statistics for counties containing uranium mines

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Alaska	Southeast[a]	1	0	0.03	44,501	1,282	1,282	0
Arizona	Apache	140	0	1.1	28,930	32,304	4,522,560	0
	Cochise	2	0	3.8	16,203	61,918	123,836	0
	Coconino	113	0	1.0	48,019	48,326	5,460,838	0
	Gila	18	0	2.4	12,297	29,255	526,590	0
	Graham	1	0	1.4	11,961	16,578	16,578	0
	Maricopa	3	0	41.	23,711	971,228	2,913,684	0
	Mohave	5	0	0.76	34,232	25,857	129,285	0
	Navajo	35	1	2.3	25,666	59,649	2,088,715	59,649
	Pima	2	1	19.	23,931	443,958	887,916	443,958
	Santa Cruz	3	0	4.3	3,227	13,966	41,898	0
	Yavapai	3	0	1.8	20,956	37,005	111,015	0
California	Imperial	2	0	6.8	10,984	74,492	148,984	0
	Inyo	1	0	0.77	26,237	17,259	17,259	0
	Kern	6	0	17	21,113	349,874	2,099,244	0
	Lassen	2	0	1.4	11,816	16,796	33,592	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
California	Madera	1	0	7.5	5,556	41,519	41,519	0
	Mono	1	0	0.51	7,840	4,016	4,016	0
	Riverside	5	0	25.	18,586	456,916	2,284,580	0
	San Bernardino	3	0	14	52,103	696,871	2,090,613	0
	Sierra	[illegible]	0	1.2	2,481	2,842	2,842	0
	Tuolumne	1	0	4.6	5,832	25,996	25,996	0
Colorado	Boulder	7	0	68	1,937	131,889	923,223	0
	Clear Creek	4	0	4.8	995	4,819	19,276	0
	Custer	3	0	0.59	1,909	1,120	3,360	0
	Dolores	6	0	0.62	2,657	1,641	9,846	0
	Eagle	2	0	1.7	4,353	7,498	14,996	0
	El Paso	1	0	42	5,587	235,972	235,972	0
	Fremont	25	0	6.6	4,022	26,545	663,625	0
	Garfield	10	0	2.3	7,759	17,845	178,450	0
	Gilpin	4	0	5.0	383	1,915	7,660	0
	Grand	4	0	0.86	4,802	4,107	16,428	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Colorado	Gunnison	1	0	1.2	8,339	10,006	10,006	0
	Hinsdale	1	0	0.19	2,729	519	519	0
	Huerfano	2	0	1.6	4,077	6,590	13,180	0
	Jefferson	13	1	120	2,028	235,368	3,059,784	235,368
	La Plata	3	0	5.4	4,358	23,533	70,599	0
	Larimer	5	0	17	6,762	114,954	574,770	0
	Mesa	185	20	7.3	8,549	62,407	11,545,295	1,248,140
	Moffat	18	3	0.77	12,284	9,459	170,262	28,377
	Montezuma	6	1	2.7	5,423	14,642	87,852	14,642
	Montrose	479	63	3.5	5,796	20,286	9,716,994	1,278,018
	Park	7	0	0.77	5,599	4,311	30,177	0
	Pitkin	1	0	3.5	2,520	8,820	8,820	0
	Pueblo	1	0	20	6,228	124,560	124,560	0
	Rio Blanco	26	0	0.77	8,451	6,507	169,182	0
	Saguache	13	1	0.39	8,142	3,175	41,275	3,175
	San Juan	2	0	0.77	1,012	779	1,558	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Colorado	San Miguel	339	25	0.77	3,322	2,557	866,823	63,925
	Teller	3	0	3.9	1,432	5,584	16,752	0
Idaho	Custer	5	0	0.23	12,766	2,967	14,835	0
	Lemhi	1	0	0.39	11,862	6,395	6,395	0
Montana	Broadwater	1	0	0.82	3,090	2,526	2,526	0
	Carbon	11	0	1.5	5,325	7,797	85,767	0
	Fallon	1	0	0.96	4,229	4,050	4,050	0
	Hill	1	0	2.3	7,581	17,358	17,358	0
	Jefferson	3	0	1.5	4,278	6,839	20,517	0
	Madison	1	0	0.55	9,138	5,014	5,014	0
Nevada	Clark	2	0	16.2	20,393	330,714	661,428	0
	Elko	3	0	0.31	44,452	13,958	41,874	0
	Humboldt	1	0	0.25	25,128	6,375	6,375	0
	Lander	2	0	0.39	14,558	2,992	5,984	0
	Lincoln	2	0	0.19	27,114	2,647	5,294	0
	Lyon	2	0	1.9	5,257	10,508	21,016	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Nevada	Mineral	2	0	0.71	9,751	7,051	14,102	0
	Nye	1	0	0.12	46,786	5,599	5,599	0
	Washoe	6	0	8.9	16,487	144,750	868,500	0
New Jersey	Sussex	1	0	73	1,364	99,299	99,299	0
New Mexico	Catron	4	0	0.12	17,863	2,198	8,792	0
	Dona Ana	1	0	7.1	9,852	69,773	69,773	0
	Grant	3	0	2.1	10,282	22,030	66,090	0
	Harding	1	0	0.25	5,527	1,348	1,348	0
	Hidalgo	1	0	0.53	8,927	4,734	4,734	
	McKinley	73	35	3.5	14,138	49,483	3,612,259	1,731,905
	Mora	1	0	0.93	5,025	4,673	4,673	0
	Quay	3	0	1.5	7,446	10,903	32,709	0
	Rio Arriba	8	0	1.9	15,133	28,752	230,016	0
	Sandoval	3	0	2.3	9,619	22,123	66,369	0
	San Juan	41	0	4.6	14,245	65,527	2,686,607	0
	San Miguel	3	0	1.8	12,279	21,951	65,853	0
	Santa Fe	2	0	13	4,926	64,038	128,076	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
New Mexico	Sierra	6	0	0.67	10,790	7,189	43,134	0
	Socorro	7	0	0.57	17,102	9,763	68,341	0
	Taos	1	0	3.0	5,843	17,516	17,516	0
	Valencia	19	4	3.1	14,649	45,411	862,809	181,644
North Dakota	Billings	9	0	0.39	2,950	1,153	10,377	0
	Slope	1	0	0.39	3,172	1,360	1,360	0
	Stark	3	0	5.8	3,408	19,650	58,950	0
Oklahoma	Caddo	2	0	8.8	3,294	28,931	57,862	0
	Custer	1	0	8.3	2,538	21,040	21,040	0
Oregon	Crook	1	0	1.3	7,705	9,985	9,985	0
	Lake	2	0	0.34	21,318	7,158	14,316	0
South Dakota	Butte	3	0	1.3	5,827	7,825	23,475	0
	Custer	10	0	1.2	4,032	5,196	51,960	0
	Fall River	93	0	1.9	4,514	8,066	750,138	0
	Harding	28	0	0.39	6,946	1,879	52,612	0
	Lawrence	2	0	8.4	2,072	17,453	34,906	0
	Pennington	5	0	8.3	7,198	59,349	296,745	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Texas	Briscoe	2	0	1.2	2,264	2,794	5,588	0
	Burnet	1	0	4.4	2,577	11,420	11,420	0
	Crosby	1	0	3.9	2,359	9,085	9,085	0
	Garza	6	0	2.8	2,367	6,611	39,666	0
	Gonzales	2	0	5.8	2,735	16,342	32,684	0
	Karnes	23	10	6.6	1,963	12,955	297,965	129,550
	Live Oak	6	5	2.3	2,732	6,453	38,718	32,265
Utah	Beaver	9	1	0.77	6,692	5,152	46,368	5,152
	Box Elder	1	0	1.9	14,512	28,129	28,129	0
	Duchesne	4	0	1.5	8,430	12,645	50,580	0
	Emery	186	18	0.39	11,497	4,483	833,838	80,694
	Garfield	131	15	0.39	13,359	5,210	682,510	78,150
	Grand	164	17	0.77	9,536	7,342	1,204,088	124,814
	Iron	1	0	1.4	8,547	12,177	12,177	0
	Juab	4	0	0.52	8,837	4,574	18,296	0
	Kane	3	0	0.39	10,111	3,943	11,829	0

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Utah	Piute	10	0	0.77	1,952	1,503	15,030	0
	San Juan	241	24	0.77	19,961	15,369	3,703,929	368,856
	Sevier	2	0	2.3	4,996	11,490	22,980	0
	Uintah	14	0	1.5	11,621	17,431	244,034	0
	Washington	6	0	2.7	6,285	16,969	101,814	0
	Wayne	32	0	0.39	6,438	2,510	80,320	0
Washington	Pend Oreille	3	0	1.9	3,631	7,361	22,083	0
	Spokane	9	0	67	4,553	306,338	2,757,042	0
	Stevens	1	2	3.5	6,425	22,489	22,489	44,978
Wyoming	Albany	4	0	2.3	11,002	25,304	101,216	0
	Big Horn	9	0	1.5	8,176	12,264	110,376	0
	Campbell	55	0	1.2	12,318	14,781	812,955	0
	Carbon	16	3	0.77	20,473	15,764	252,224	47,292
	Converse	31	5	0.77	11,087	8,536	264,616	42,680
	Crook	23	0	0.77	7,464	5,747	132,181	0
	Fremont	65	13	1.2	23,817	28,580	1,857,700	371,540

Table 5.1 (Continued)

State	County	Number of Uranium Mines Inactive	Number of Uranium Mines Active	Population Density (persons/km^2)	County Area (km)^2	County Population (persons)	Person-Mines Inactive	Person-Mines Active
Wyoming	Johnson	15	0	0.39	10,813	4,217	63,255	0
	Natrona	16	2	3.9	13,835	53,956	863,296	107,912
	Niobrara	13	0	0.39	6,770	2,640	34,320	0
	Sublette	1	0	0.39	12,564	4,899	4,899	0
	Sweetwater	4	2	1.2	27,011	32,413	129,652	64,826
	Washakie	2	0	1.5	5,858	8,787	17,574	0
	Weston	1	0	1.0	6,234	6,307	6,307	0
				Average Population Density	Total County Area (km)^2	Total County Population	Total Person-Mines (Inactive)	Total Person-Mines (Active)
				4.4 persons/km^2	1,492,136	6,625,099	82,327,885	14,035,161

Note.--Population statistics from (DOC78).
(a)Congressional District.

5.1.5 Population Statistics of Humans and Beef Cattle

Table 5.2 lists some population statistics for humans in New Mexico and Wyoming, humans in all uranium mining states, and beef cattle in New Mexico and Wyoming.

Table 5.2 Population statistics for humans and beef cattle

Total Human and Beef Cattle Population Within 80 km Radius of Mines			
	New Mexico	Wyoming	All Uranium Mining States
Human	447,412	224,195	6,625,099
Beef cattle	753,000	905,000	----------
Average Human and Beef Cattle Population Densities Within 80 km Radius of Uranium Mines (number/km^2)[a]			
Human	2.4	1.3	4.4
Beef Cattle	4.1	5.1	----

[a]Areas taken from Table 5.1: New Mexico = 183,646 km^2; Wyoming = 177,422 km^2, and the total county area = 1,492,136 km^2.

5.2 Prominent Environmental Pathways and Parameters for Aqueous Releases

From a computer code prepared within EPA, we calculated annual committed dose equivalents to individuals and annual collective dose equivalents to a population for these assessments. Table 5.3 lists the aqueous pathways that were initially considered potential pathways of exposure. As indicated in Table 5.3, these pathways result in computation of dose equivalents due to inhalation, ingestion, ground surface exposure, and air submersion. For above surface crop ingestion, milk ingestion, and beef ingestion (pathways 3, 4, and 5), we considered only uptake through the plant root systems to predict concentrations of radionuclides in crops, since essentially all irrigation is ditch irrigation. Appendix J contains a detailed explanation of the environmental transport and dosimetry models used in these analyses.

The maximum individual for the aquatic pathways is the individual at maximum risk. He is exposed to radionuclides discharged in mine effluent through pathways 2 through 10 of Table 5.3. The water contributing radionuclides to these pathways comes from a creek into which a mine discharges. The average individual is exposed to the average risk of all persons included in the population of the assessment area. He is exposed to radionuclides discharged in mine effluent through pathways 2 through 8 and 10 of Table 5.3. The water contributing radionuclides to these pathways is taken from the regional river after the creek water has been diluted in this river. The population considered in the assessment of the aquatic pathways is obtained by multiplying the regional assessment area size by the population density within this area. This assessment area contains the drainage basin for the mine effluent stream, the creek and the regional river discussed in defining the maximum and average individuals.

5.2.1 Individual Committed Dose Equivalent Assessment

Section 6 of this report contains the computed dose equivalents to the maximum individual and to the average individual. For the maximum individual, we included all pathways in Table 5.3 except drinking water (pathway 1). It is known that the releases to the aquatic environment occur through discharge of mine water to surface streams. Potentially, drinking water could be one of the most significant pathways for the maximum individual dose equivalents, if surface water containing mine wastes was drunk. However, it appears that all drinking water for both the New Mexico and the Wyoming sites comes from wells (Robert Kaufmann, 1979, U.S. Environmental Protection Agency, Las Vegas, NV, personal communication). Thus, the only way mine discharges can enter human drinking water is by percolating through the soil. Since we do not know the soil chemistry for these sites well enough to predict the ion-exchange parameters for the soil, we can not predict, realistically, the quantity of mine-related radionuclides that would reach the groundwater. We expect that these ion-exchange factors would be large for several of the radionuclides considered in these analyses and that groundwater concentrations of radionuclides discharged in mine water would be quite small compared to concentrations in the surface water downstream from the mines. Further study is needed before dose equivalents for the maximum individual by drinking groundwater can be adequately addressed.

The following are other assumptions used to calculate maximum individual dose equivalents:

1. Ground surface concentrations of radionuclides (used for pathways 6 through 8) are for 8.5 years, the assumed midpoint of mine life. The assumed period of mine operation is 17 years. The organ annual dose equivalents for the external surface exposure pathway are based on the ground concentrations after the 8.5 years buildup time.
2. For inhaled or ingested radionuclides, the dose equivalents are the annual committed dose equivalents that will be accumulated over 70 years after intake for an adult.

We calculated dose equivalents to the average individual in the assessment area by taking the population dose equivalents (discussed in Subsection 5.2.2) and dividing by the population living in the area.

Table 5.3 Aquatic environmental transport pathways initially considered

Pathway No.	Pathway
1	Drinking water ingestion
2	Freshwater fish ingestion
3	Above surface crops ingestion - irrigated cropland
4	Milk ingestion - cows grazing on irrigated pasture
5	Beef ingestion - cows grazing on irrigated pasture
6	Inhalation - material resuspended which was deposited during irrigation
7	External dose due to ground contamination by material originally deposited during irrigation
8	External dose due to air submersion in resuspended material originally deposited during irrigation
9	Milk ingestion - cows drinking contaminated surface water
10	Beef ingestion - cows drinking contaminated surface water

5.2.2 Collective (Population) Dose Equivalent Assessment

For the population dose equivalent assessment calculations, we concluded that the pathways of concern are pathways 2, 3, 4, 5, 6, 7, 8, and 10 of Table 5.3 (detailed discussion in Appendix J, subsection J2). The size of the assessment areas for New Mexico is 19,037 km^2 and 13,650 km^2 for Wyoming. We used the following considerations to calculate population dose equivalents for the assessment area:

1. Ground surface concentrations of radionuclides are for 8.5 years, the assumed midpoint mine life. (The period of mine operation is 17 years.) The organ annual collective dose equivalent rates for the external surface exposure pathway are based on the ground concentrations after the 8.5 year buildup time.

2. For inhaled or ingested radionuclides, the dose equivalents are the annual collective dose equivalents that will be accumulated over the 70 years after intake for adults.

3. The population distributions around the sites are based on estimates by county planners (John Zaboroc, 1979, Converse Area Planning Office, Douglas, Wyoming, personal communication) and agricultural personnel (Tony Romo, 1979, Valencia County Agent, Los Lunas, New Mexico, personal communication) for 1979. The populations, assumed to remain constant in time, were estimated to be 16,230 and 64,950 persons in the Wyoming and New Mexico assessment areas, respectively.

4. Average agricultural production data for the county which contains a major portion of the assessment area are used.

5. The population in the assessment area eats food from the assessment area. We assume that any imported food is free of radionuclides.

As mentioned previously, Appendix J contains the details regarding the models and values for parameters used in these analyses.

5.3 Prominent Environmental Pathways and Parameters for Atmospheric Releases

We used the AIRDOS-EPA (Mo79) computer code to calculate radionuclide air and ground concentrations, ingestion and inhalation intakes, and working level exposures; and we used the DARTAB (Be80) computer code to calculate dose and risk from the AIRDOS-EPA intermediate output using dose and risk factors from the RADRISK (Du80) computer code. We calculated working levels associated with Rn-222 emissions assuming that Rn-222 decay products were 70 percent in equilibrium with Rn-222, a value considered representative of indoor exposure conditions (Ge78). Appendix K contains a detailed discussion of the application of the AIRDOS-EPA and RADRISK computer codes.

Figure 5.1 shows the general airborne pathways evaluated for uranium mines. We calculated doses due to air immersion, ground surface exposure, inhalation, and ingestion of radionuclides, but we did not address the resuspension pathway, since the AIRDOS-EPA code did not provide a method for calculating resuspended air concentrations or subsequent redeposition to the ground surface. We used the modification to the AIRDOS-EPA computer code made by Nelson (Ne80) to include the effect of environmental removal of radioactivity from the soil. For ingestion, transfers associated with both root uptake and foliar deposition on food and forage are considered.

5.3.1 Individual Committed Dose Equivalent Assessment

We assessed the maximum individual on the following basis:

1. The maximum individual for each source category is intended to represent an average of the individuals living close to each model uranium mine. The individual is assumed to be located about 1600 meters from the center of the model site.
2. Ground surface concentrations of radionuclides used in the assessment are those that would occur during the midpoint of the active life of the model uranium mine. Buildup times used in the assessment are 8.5 years for active surface and underground mines, 5 years for the in situ leach mine, and 26.5 years for the inactive surface and underground mines. The 26.5-year buildup time for the inactive mines is chosen to represent the midpoint of the 53-year exposure time that a resident living a lifetime in the region around the model mine is estimated to experience. The organ dose equivalent rates for the external surface exposure pathway are based on

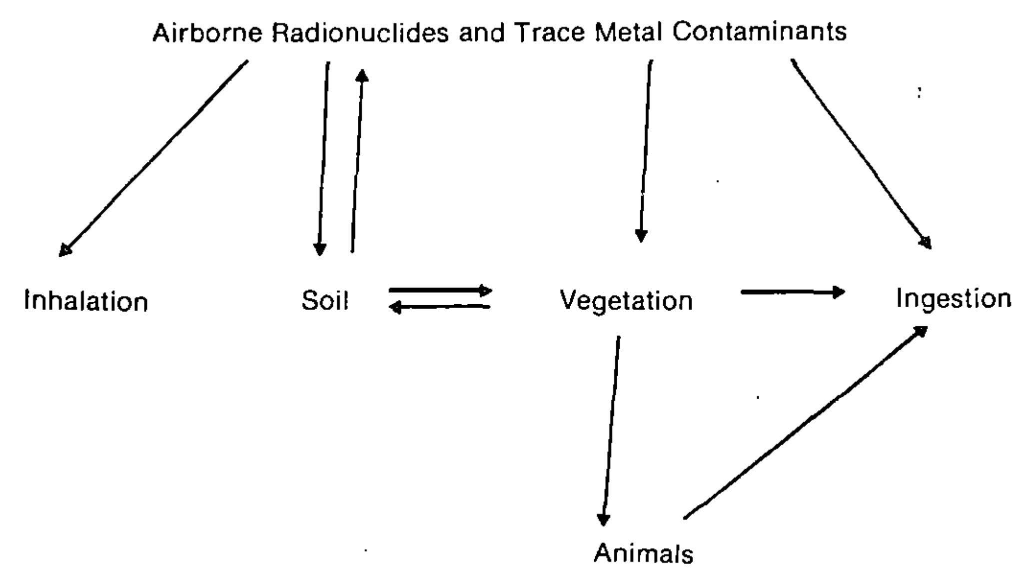

Figure 5.1 Potential airborne pathways in the vicinity of uranium mines.

the concentrations for the indicated buildup time.

3. For inhaled or ingested radionuclides, the dose equivalent rates are actually the 70-year committed dose equivalent rates for an adult receptor, i.e., the internal dose equivalent that would be delivered up to 70 years after an intake. The individual dose equivalent rates in the tables are in units of mrem/yr.

4. The individual is assumed to home grow a portion of his or her diet consistent with the rural setting for each model uranium mine site. Appendix K contains the actual fractions of home-produced food consumed by individuals for the model mine sites. The portion of the individual's diet that was not locally produced is assumed to be imported and uncontaminated by the assessment source.

5.3.2 Collective (Population) Dose Equivalent Assessment

The collective dose equivalent assessment to the population out to 80 km from the facility under consideration is performed as follows:

1. The population distribution around the model mine sites is based on the 1970 census. The population is assumed to remain constant in time.
2. Ground surface concentrations and organ dose equivalent rates for the external surface exposure pathway (as for the individual case) are those that would occur over the active life of the model mine.
3. Average agricultural production data for the state in which the model uranium mine is located are assumed.
4. The population in the assessment area eats food from the assessment area to the extent that the calculated production allows, and any balance is assumed to be imported without contamination by the assessment source.
5. Seventy-year committed dose equivalent factors for an adult receptor (as for the individual case) are used for ingestion and inhalation.

5.4 Mine Wastes Used In the Construction of Habitable Structures

Using uranium mine wastes under or around habitable structures or building habitable structures on land contaminated with uranium mine wastes can result in increased radiation exposures to individuals occupying these structures. The radium-226 present in these wastes elevates the concentrations of radon-222 and its decay products and produces increased gamma radiation inside these structures. The health risk to individuals occupying these structures is generally much greater from inhaling radon-222 decay products than the risk received from gamma radiation.

Radon-222, formed from the decay of radium-226, is an inert gas that diffuses through the soil and migrates readily through foundations, floors, and walls and accumulates in the inside air of a structure. Breathing radon-222 and its short-lived decay products (principally polonium-218, bismuth-214, and polonium-214) exposes the lungs to radiation.

The radon-222 decay product concentration (working level) inside a structure from radon-222 gas diffusing from underlying soil is extremely variable and influenced by many complex factors. These would include the radium-226 concentration of the soil, the fraction of radon-222 emanating from the soil, the diffusion coefficient of radon-222 in soil, the rate of influx of radon-222 into the structure, the ventilation rate of the structure, and the amount of plate-out (adsorption) of radon-222 decay products on inside surfaces.

The potential risks of fatal lung cancer that could occur to individuals living in homes built on land contaminated by uranium mine wastes have been estimated using measurements and calculational methodology relating radon-222 decay product concentrations inside homes to the radium-226 concentrations in outside soil (He78, Wi78). These estimates are shown in Section 6.1.5.

5.5 References

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